The Vicuna in Bolivia: The Status of an Endangered Species, and Recommendations for its Conservation

By Hartmut Jungius

From the Institut für Haustierkunde der Christian-Albrechts-Universität Kiel
Direktor Prof. Dr. Dr. h. c. W. Herre

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Introduction

The vicuna belongs to those mammals which have been subjected to an intensive management for centuries. Due to this, particular means of conservation became necessary soon to preserve the stocks for obtaining permanent profits from its products. The wool and the fleece in particular and according to Eaton (1925) the meat as well (however the latter is denied by Horkheimer [1960]) made the vicuna the most important wild South American mammal of precolumbian times, which was harvested systematically by the Incas. Cardozo (1957), Koford (1957), Herre (1963) and other authors studied old reports and explained the management of the Incas, into the particulars of which I do not want to enter. It need only be mentioned that all vicunas in an area were rounded up once in 3 years. The wool was taken from all and some were killed, but the majority was released again. Under Inca rule the wool was needed to produce the finest fabrics which were dedicated to the service of the temples of the sun, either as decorations or worn by the priests. This valuable material was never devoted to other objectives and the Inca watched carefully that no illegal hunting took place, therefore the population was never in danger, despite severe utilization. After the breakdown of the Inca empire, the catastrophe for the vicuna began. The Indians and the Spanish conquerors did not feel responsible for the old laws, and uncontrolled hunting started, because wool and skins were still highly prized. Cabrera and Yepes (1960) report that approximately 80 000 vicunas were killed per year during the 16th century, and thus the menace for this species became visible very early.

However, it took a long time, until governmental organizations recognized the danger for the vicuna. It was left to the great South American hero Simon Bolivar to issue the first decrees in 1825 which prohibited the killing of this animal in Peru. But these laws did not have much success and in 1876 Napp (after Kirk 1960) predicted the quick extermination of the vicuna if this steady persuit continued. A great many laws in Peru, Argentina, Chile and Bolivia tried to stop this sudden decline, but new traditions which had already been established during 300 years could not be weakened and in 1950 only a few more than 400 000 specimens were left from a millionfold population (Koford 1957, Röhrs 1957).

Yet, it would not have been too late for significant action and a systematic management of the remaining stocks would still have been possible (see below). But as reckless overhunting continued, despite the warnings of well known zoologists (Koford 1957, Herre 1963), the rest of the population decreased so rapidly that today we are confronted with the total crash of the population and even have to fear the total extermination of the vicuna if effective precautions are not applied immediately. In 1969 the vicuna was included in the Red Data Book of IUCN and in 1970 a Vicuna-Group

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was established by the SSC with Prof. Dr. Dr. h. c. W. Herre in the chair. The group works in co-operation with WWF, IUCN and UN-Agencies, and it has the difficult task of working out means of protection for the last vicunas and to initiate studies for its conservation.

I. Range and Present Stocks

There are few reliable sources on the vicuna's former distribution. Krumbiegel (1944, 1952) reports already in 1943 that the southern range is in latitude 33° S while it was still common in middle Chile 100 years ago (in 1850, recorded by Gillis after Krumbiegel 1943), Osgood (1943) records on the other hand: ". . . confined to rather remote parts of the higher Andes" and "that knowledge of this animal in Chile is very scanty and the southern limits of its range are much in doubt". More recent data are available by Koford (1957) and Röhrs (1958), the latter states the southern limits of the range to be along the line Vallenar (Chile) — La Rioja (Argentine) in latitude 29° S. The expedition Herre / Röhrs was able to confirm vicunas personally in the Cachima mountains and near La Quiaca on the Argentina/Bolivian boundary. While Röhrs assumed that vicunas occur definitely in the northern provinces of Argentina (Salta and Jujuy), we must presume that only small groups were able to survive until today in remote areas of the northern cordillera within these provinces. This has been reported to me by W. Everts who has just returned from a zoological expedition to Argentina. C. Cordier informed me that only small groups are expected to exist still in Chile along its northeastern boundary with Bolivia in the latitude of Sabaya — Sajama (Fig. 1).

Summing up the situation in Chile and Argentina we can state that vicunas are nearly exterminated in these countries and that we can not expect more than 100 individuals. I do not share the opinion of Bate (1968) that the vicuna is already eliminated from these countries until this is confirmed by comprehensive studies.

More detailed information is available from the 2 present main distribution areas of the vicuna. Grimwood (1969) estimates that 5 000 to 10 000 animals remain in Peru. After my work in Bolivia I came to the conclusion there may be hardly more than 1000 to 1500 in this country. Today the northern boundary of its distribution is to be found in latitude 9° 30' in the Peruvian province of Ancash. Grimwood's estimation, that the vicuna has never occurred north of 9° 30' S cannot be supported, because there are several statements which mention vicunas in these areas (Allen 1942, Cardozo 1957, Cabrera & Yepes 1960. This report is also incompatible with the fact that vicunas still occurred in historical times in Ecuador. Röhrs (1957) mentions that the northern range of the vicuna was between Junin and Cerro de Pasco in 1956/57.

On the basis of this summary we can assume a total population of about 10 000 animals today. This implies that nearly 400 000 have been slaughtered during the past 20 years, which corresponds to an annual average of 20 000. Also this uncontrolled hunting caused a reduction in the range of the vicuna, and thus there are only insular populations left within its former distribution area. Grimwood (1969) calculated that in these areas the largest numbers are still to be found in Peru. Because comprehensive stock-taking is the basis for all future conservation attempts, it is to be regretted that similar studies are not available from other „Vicuna-countries". To close this gap in the case of Bolivia, is one aim of this paper. Some of the presented data result from my own observation tours during a 6 month stay in Bolivia, others were obtained from observations by R. Pujol, a member of the Museum of Natural History in Paris and by C. Cordier, an animal catcher of very good international reputation, who has worked many years in this country. I want to express my very sincere appreciation and gratitude to both of them. Grateful acknowledgement is also made to Dr. A. Cardozo

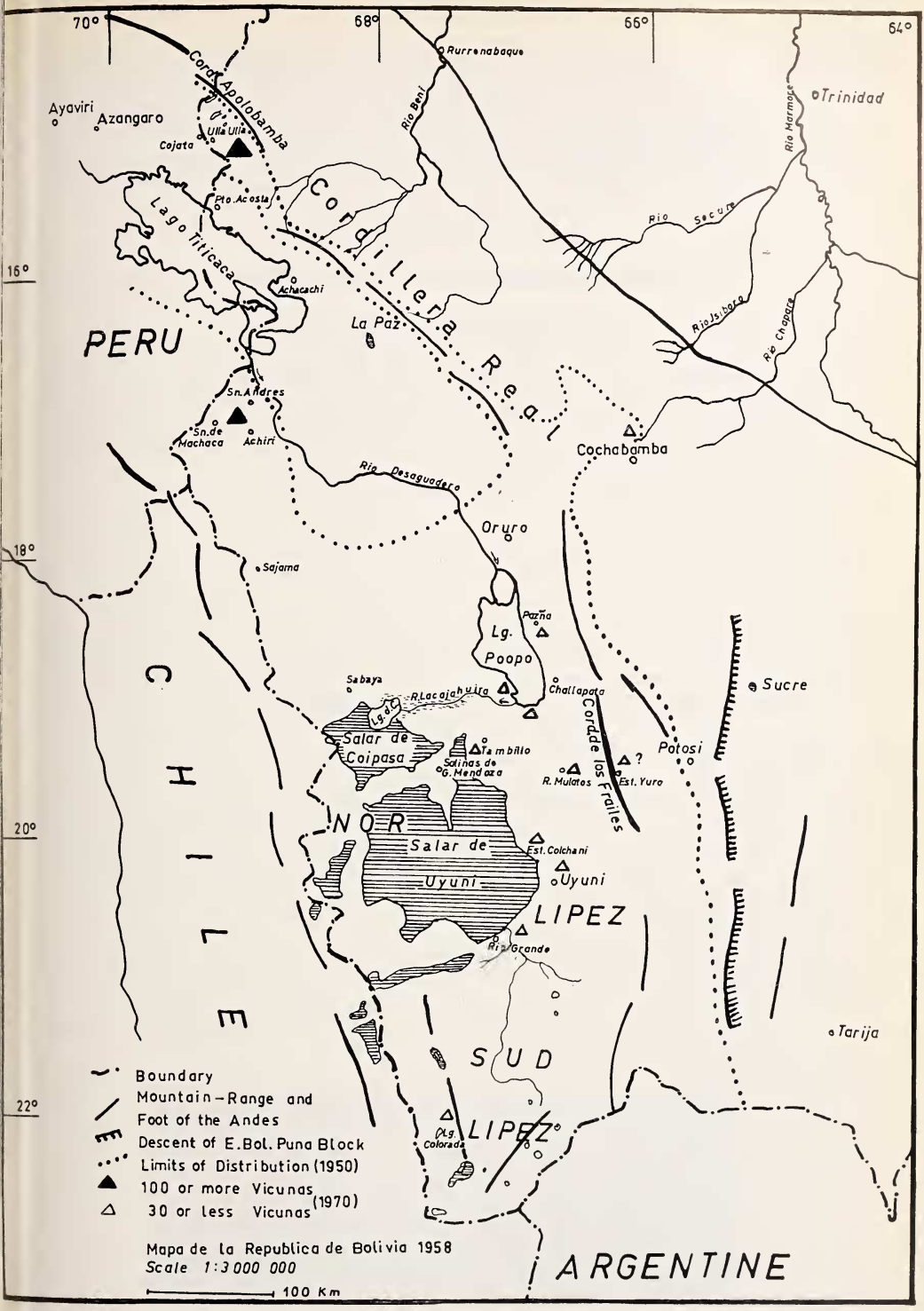

Fig. 1. Distribution of the vicuna in Bolivia

for his encouraging and unselfish aid, moreover I am very much obliged to Ing. P. Baptista and W. Terrazas from the Dpto. Forestal Caza Pesca, who supplied me with information and accompanied me on my trips. However, I am fully aware that these statements can not be definitive, despite this co-operation, and they will have to be completed by further studies. Yet they do represent a broad survey of the whole Bolivian situation and give the approximate numbers of the present vicuna-population in this country.

II. Distribution of the Vicuna in Bolivia

1. Former distribution

Authentic new information is only made available by Koford (1957) and the South American Expedition Herre / Röhrs 1956/57. From these records and my own investigations as well as from support of Prof. Dr. Dr. Herre, to whom I want to express my gratitude, it is possible to establish the following picture of the vicuna's distribution 20 years ago (see Fig. 1).

a. Altiplano: The Bolivian Altiplano, including the edges of the Salar de Uyuni and Salar de Coipasa have been populated continuously by vicunas, even though in varying density, around 1950 (Cardozo pers. comm., Röhrs 1957). Due to the sparse vegetation (see below), and the dry conditions the population density was certainly always very low. Koford's estimation of 1 vicuna per 400—500 ha is surely right, if not even too low for many areas. Nearly half of the vicuna's range in Bolivia is situated in these dry areas south of the Salar de Uyuni and Lago Poopo. This area comprises about 90 000 km², and accordingly it could carry only a maximum of 20 000 animals. For 1950 Koford assumed there may be a maximum of 150 000 specimens outside Peru; even if we suppose these figures to be very high, one can expect that this marginal area still carried an important vicuna population despite its low density 20 years ago. Parts of the eastern Altiplano, particularly the eastern rim of the Oruro-Lago Poopo basin are more humid and thus make a more luxurious vegetation possible, on the basis of which a higher vicuna concentration can thrive. But this favourable climate produces on the other hand an increase in the human population density which implies a higher concentration and competition by domestic stock and an intensified pressure on the vicunas due to increased hunting. Therefore it can be assumed that vicunas have certainly not been more plentiful in this region than in the south.

b. Cordillera: The cordillera which encloses the Altiplano in the E and W has to be considered as another traditional lebensraum (habitat) and in suitable biotopes vicunas are found up to the snowline (5300 m), Fig. 2. Not only dry gravel plains are populated, but particularly so-called moist puna-areas ("bofedal" or "patano"). I could

Fig. 2. Vicunas on a gravel plain near the snow-line

make my own observations on this in the southern (Cord. de los Frailes) and northern parts of the eastern Cord. HERRE (pers. comm.) observed as well high vicuna concentration in the Cord. west of Potosi. All these bofedals represent well watered vicuna biotops which were once densely populated by this species. But due to severe competition by livestock and overhunting by people, vicunas have been displaced as well, to an increasing extent particularly during the last 20 years (s. b.).

2. Present distribution (Fig. 1)

a. Altiplano: Statements on the southern part of the Altiplano refer mostly to reports by PUJOL and CORDIER.

Sud-Lipez: PUJOL observed 7–8 animals without lambs 3 km north of Laguna Colorada (5.69) and CORDIER met with a tropp of 7 animals near the lagoon. Both agree to the fact that large troops are hardly seen in the whole area between Uyuni and Laguna Verde in the extreme south. PUJOL saw none and also CORDIER holds the opinion that one will never meet more than 3–4 vicunas. On account of the sparse vegetation the vicuna density was always very low here, but now we must presume that it is about to disappear totally, in particular because no young animals have been reported. If family bands had been observed we must fear that lambs have been killed by poachers.

Nor-Lipez – Lago Poopo: PUJOL reported 8 vicunas and one yearling from the eastern parts of the Salar de Uyuni (6. 5. 69) and 10–12 vicunas 8–10 km north of Uyuni without lambs. I did not find vicunas myself when I travelled in the same area between Challapata and Uyuni on 31. 5. and 1. 6. Due to inquiries a small group (of about 10) is said to occur east of Rio Mulatos (Pampa de Chiru). CORDIER reports 25 vicunas from the south of Salar de Uyuni near the railway station of Rio Grande near to the place were the river of the same name enters the salar. This observation originates from 1963 and it is doubtful if this troop exists still in the same number.

Smaller populations occur around the southern part of Lago Poopo and along its eastern shore, a small troop of about 11 animals near Pazna and others between Tambillo and Salinas de Garci Mendoza (CORDIER pers. comm.). Because it is likely that modest numbers of vicunas remain undiscovered in remote areas, we may assume that there exist still about 100 to 150 animals in the districts of Sud and Nor Lipez.

NW of Lg. Poopo – Oruro – Sajama – Sabaya: Here the vicuna is considered to be nearly exterminated (CARDOZO per. comm.). CORDIER did not find any, on one of his extensive travels from Oruro following the railwayline to the north and then turning westward to the Sajama from there along the Chilenean boundary to Sabaya and then south to the Salar de Uyuni. Even in remote areas NW of Sabaya the vicuna seems to be exterminated. Some troops are only said to persist on the Chilean side, but there they are persecuted by Carabineros with cars.

b. Eastern Cordillera: 6 to 8 years ago the area around the Est. Yura (Cord. de los Frailes) was populated by hundreds of vicunas. When I visited this area in June 1969 we did not find a single vicuna nor did we see any tracks despite travelling in distant pampas and descending into remote valleys. Apart from one troop which possibly still exists southwest of the railway station we must assume that they are exterminated. The situation is similar in other good vicuna habitats. Due to extermination most of this country is uninhabited, and also domestic stock is hardly to be found (Fig. 8). In the cordillera north of Cochabamba another small population exists. The largest continuous concentration of vicunas in Bolivia occurs in the Cordillera de Apolobamba around the village of Ulla-Ulla. According to my own investigations (JUNGIUS 1970) I expect about 150 animals there. To the south near Pumasani persist other small troops of altogether 25 animals (NOGALES pers. comm.). If we include

remote areas which have not been inspected, but where possibly vicunas still live, we can estimate a total population of 300 to 400 specimens in the eastern cordillera.

c. Foreland of the western cordillera and Altiplano westward of Rio Desaguadero until the Sajama: Assured reports are available from the area around Salinas de Machaca where about 120 vicunas occur with 40 to 50 near Huacarani in the north, 20—30 near San Andres and another 20—30 between Santiago de Machaca and Achiri. From there to the south only negative information has been obtained. If vicunas exist at all, there can only be small scattered troops.

Summary and Conclusion

Resulting from the presented information, the vicuna stocks of Bolivia can be estimated to include about 1000 and maximum 1500 animals. The largest population exists in the extreme northwest in the Apolobamba around Ulla-Ulla. Further isolated populations occur in the eastern cordillera and along the western boundary of Bolivia south of Lake Titicaca. These groups may be rebuilt and increased to larger populations under careful management.

In the dry and desert puna of the southern Altiplano the situation must be considered to be very dangerous, because only a few scattered troops seem to have survived. Due to the low numbers the difficult living conditions and the low rate of reproduction (compared with better biotopes) survival for the future must be doubtful, if appropriate precautions for its conservation are not undertaken immediately.

III. Evolution and Utilization of the Vicuna Habitats in Bolivia

From the statements made above one can deduce that the vicuna has been nearly eliminated from all good habitats. The reason for this was overhunting and the competition for pasture and space by livestock. Apart from this, small vicuna populations succeeded in surviving in remote parts with poor vegetation which always constituted characteristic vicuna habitats (with low population densities), if permanent water was available.

Today the dry regions of the western and southern Altiplano and the dry gravel plains of the higher puna areas, have to be considered as typical areas of retreat. Due to the low development of these marginal areas, its inaccessability and the low human population density, the vicuna managed to escape extermination. For the conservationist these last refuges of the vicuna are of great importance for the future protection of the species. Therefore these regions should be subjected to a quick ecological survey, on the basis of which alone decisive actions for the vicuna's conservation can be started.

1. Altiplano

The Altiplano is a high mountain plateau in the zone of the "tierra helada" which is divided up by several basins and rolling mountain ranges. It drops from Lake Titicaca in the north (3912 m) to the salars in the south (3671 m). Despite the fairly uniform character, sharp contrasts are created by the climate due to decreasing average temperature and precipitation towards the south and the west. These contrasts are very obvious between the north and the south and between east and west. According to higher rainfall the area around Lake Titicaca and the eastern rim of the basin Oruro-Poopo belongs to the "moist puna belt", the other part, which makes up the majority, is the so-called "dry puna belt", which extends in the extreme south into the "dessert puna" where the Salar de Uyuni, Salar de Coipasa and numerous small salt lakes and extensive dry gravel plains and sandy stretches are to be found (nomenclature after Troll 1968).

From our two different but traditional vicuna biotopes the zone of the dry and desert puna is the only one which is still utilized by the species today. This area represents a semi-arid country which is characterized by the following vegetation: Tola shrub of the genus Lepidophyllum, bunch grasses like Festuca orthophylla, numerous cushion plants like Azorella sp. (llareta, Fig. 8) and a cushionlike cactus Opuntia lagopus. In between this dominant vegetation many small rosette-like plants are interspersed (Werneria sp., Malvacea, etc.) short grasses and herbs, which constitute the main diet of the vicuna. Particularly on the rocky plains the vegetation is so sparsely scattered that the plants are only noticeable after a close examination. On the basis of this poor vegetation only a small number of herbivores can be permitted. PEARSON (1960) reports only a very low plant production for this biotope and states an annual harvest of 3 kg per ha for the Peruvian-Chilean dry puna, emanating from a total dry material of 2000 kg/ha. In the transitional area to the very dry south and in the regions near to the Salars, we may even calculate a lower production. This low productivity prevents large herds of herbivores from entering most parts of this region. Particularly alpacas appear in great numbers and form large concentrations (Fig. 3), which are tied to a more luxurious vegetation cover. Therefore only wild animals are able to exploit this biotope successfully, among which must be mentioned: vicuna, andean deer, many rodents like *Ctenomys, Galea, Lagidium, Chinchilla, Acodon* and others; among birds *Pterocnemia pennata, Notoprocta* sp., *Thinocorus* sp., *Tinamotis* sp., and many more. Especially the vicuna and these birds are highly specialized to life in these wide high mountain plains (MANN 1968), their slender bodies, long legs and extended necks, can be regarded as to be very typical adaptations for running.

Fig. 3. High alpaca density in a good habitat (Photo by the South-American-Expedition HERRE/RÖHRS 1956)

If we consider the adaptations of the vicuna more closely, it becomes obvious that territorial behaviour and the social structure are also decisive elements for the successful utilization of this area. Territorialism prevents crowding which would cause overgrazing and further competition, the second point prevents the formation of large herds which would soon cause trampling and food shortage. Vicunas move through these zones in small troops and are always well fed. By producing high quality wool and delicious meat on lands which are not suitable for agriculture or livestock-

breeding, the vicuna is able to represent an important resource if subjected to a sound management. Yet, on account of uncontrolled and reckless hunting this resource has been brought to the limits of its productive capacity.

2. Cordillera

The Altiplano is surrounded by high mountain ranges in the east and the west. The Bolivian Eastern-Cordillera, the peaks of which reach up to 6000 m into the "tierra nevada", will be discussed in detail because of its very typical appearance.

Between these mountain chains we always find small valleys or large basins which are dissected by rivers and creeks or occupied by lakes. Being situated right under the snow-line (5300 m) they are supplied with water all year round. Therefore a luxurious vegetation grows and extensive peat-bogs are formed, which are covered by hard and dense cushion plants, among which Distichia muscoides dominates, mixed with other species like Senecio sp., Calamagrostis sp., Werneria sp., as well as hygrophilous herbs, grasses and other Juncaceas. This succulent vegetation composes the preferred diet of the vicuna (Koford 1957, Röhrs 1957, Cabrera and Yepes 1960, own obs.). By offering these exellent living conditions this biotop represents a very traditional vicuna habitat in the mountains. However, most of these areas have been opened up to an increasing extent for alpacas, which is the most important food competitor of the vicuna.

Particularly studies in African National Parks demonstrated that various species with the same food-requirements can use the same pasture only under certain conditions:

1. Different ecological niches of the habitat are occupied.
2. One species (usually the lower ranking one) retires into marginal areas and uses another forage, which is ignored by its competitors. Thus the inferior one takes over a new nutritive resource.
3. The same habitat is utilized at different times (see Jungius 1971, Lamprey 1963, Child and Richter 1969).

The vicuna ranks as the inferior species in this interspecific competition for space and food. Therefore it normally retires from animals which appear in large herds like alpacas. Vicunas gather only in small social units which are mostly territorial (family bands, see below). Because of its behaviour patterns the vicuna avoids association with other species, like many other herbivores (Jungius 1971), which results in its total displacement from the favourite feeding sites in the central valleys. Another possibility for separating species which feed on the same pasture, is different activity patterns. However, because vicuna and alpaca are diurnal grazers which rest at night, habitat

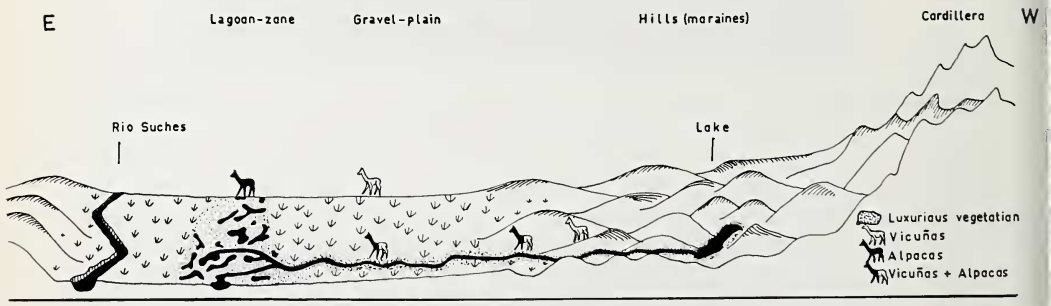

Fig. 4. Vegetation-zones at Ulla-Ulla from East to West and their utilization by alpacas and vicuans.

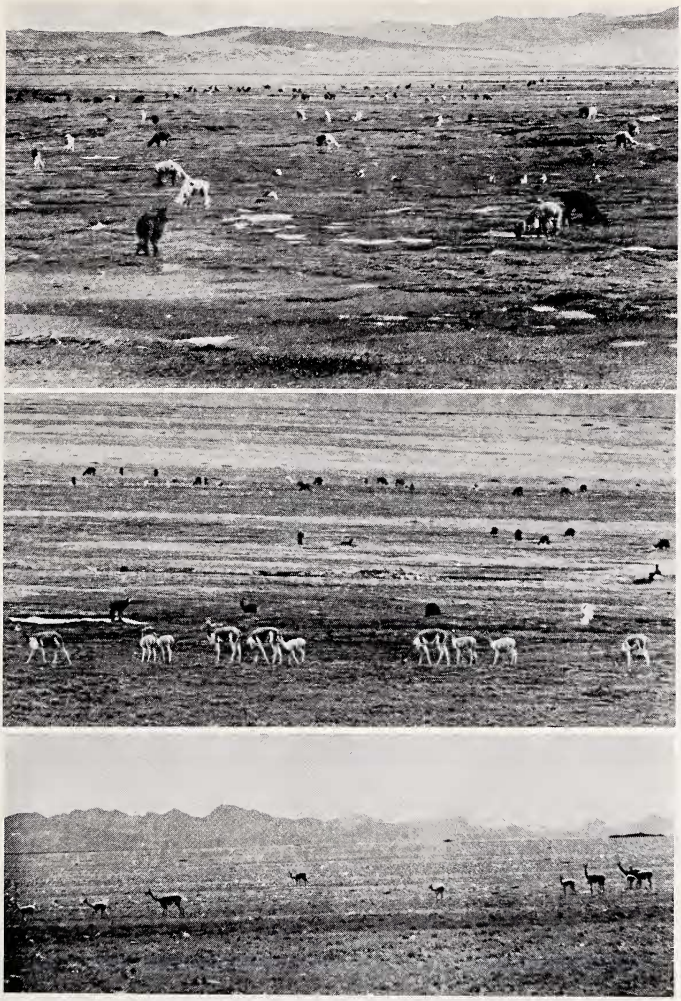

Fig. 5 (above). Alpaca concentration in a well watered habitat with luxurious vegetation at Ulla-Ulla. — *Fig. 6 (Middle)* Vicunas grazing on the outskirts of the well watered pampa and on the gravel plain, displaced by alpacas (in the background) — *Fig. 7* (below). Vicunas on a gravel plain in the Cord. de Apolobamba

utilization at different times is not possible. This results in the vicuna being forced to retire into another ecological niche, which is normally avoided by its competitors and which it utilizes almost on its own. This area is made up by the dry slopes, the gravel plains and the rolling morain country, which often joins the peat-bogs in the valleys and remains free from alpacas. An example for this situation is the region around Ulla-Ulla (Fig. 4).

The luxurious vegetation of the valley is occupied by tens of thousands of alpacas (Fig. 5) the concentration of which has already reached the carrying capacity of the range and parts of the biotope frequently show results of overgrazing. These large alpaca associations forced the vicunas to leave the favourite pasture and to retire into the bordering areas where the moist vegetation peters out, onto the transition areas of

the dry slopes (Fig. 6) and mainly on to the dry gravel plains (Fig. 7). Another preferred grazing site extends along the rivers and creeks which come from the mountains and intersect the dry slopes (Fig. 4). These riverine zones are normally only very narrow and often used by alpacas as well, when moving around during their daily activity. Because vicunas normally stay at a distance of 50 to 100 m away from alpacas, or even walk away further when they are accompanied by men and dogs, this causes the total expulsion of vicunas from good pasture and displacement to areas with poor vegetation having inferior nutritive value, which may have negative effects on the animals condition and health.

The ability of the vicuna to make use of biotopes with poor vegetation if permanent water is available, is very significant and in the future this feature should be more exploited under the principles of modern wildlife management. Moreover I was able to ascertain that vicunas utilize the river zones more intensively than alpacas, which appear only sporadically. The river forms the central zone ("core area") of the vicuna's territory. It is visited for daily drinking and frequented for grazing, because of its rich succulent vegetation. But despite this the dry slopes are used as well, whereas alpacas graze just the luxurious vegetation and in doing so they move down or up the river, continuously disturbing the vicunas (which are territorial or site-attached) or even displace them for hours, particularly if they are accompanied by people and dogs. According to this, vicunas have only temporary access to the water and therefore they need large areas for their maintenance. Without being molested, vicunas would be able to live permanently along the rivers and utilize their rich vegetation, their territorial needs would be much smaller because of increasing nutritive value, which would permit a higher population density on the other hand. If properly developed and carefully managed vicunas would represent in these areas a much greater economic advantage for the local people than the alpacas do by utilizing this zone only sporadically, for a higher concentration of vicunas would imply:

1. tourist attraction,
2. high yields of good quality wool which could be harvested once a year or every second year by shearing the animals.

Fig. 8. Good vicuna habitat in the Cord. de los Frailes, surrounded by dry hills (in the left Azorella sp.)

However, the situation of Ulla-Ulla can not be generalized. I had this experience when visiting the Cord. de los Frailes (Fig. 1). Extensive, peat-bogs of the puna type and other well watered areas were once populated densely by vicunas. Without severe or no competition by livestock high vicuna concentrations still existed there in 1957 (Herre per. comm.). When I came to this place in 1969, the vicuna was practically exterminated (see above), without livestock taking over its place, thus leaving a most valuable high mountain habitat nearly uninhabited (Fig. 8).

Bolivia, a developing country, is making great efforts to develop its natural resources in the eastern lowlands, should become aware that there are still many resources on the Altiplano which are of great potential economical, educational and cultural value, the productivity of which has been destroyed. If vicunas could be reintroduced to these areas, protected and carefully managed, a situation could be created which would produce additional income for the national economy and provide new possibilities for intensified studies and new research for national and international wildlife biologists and other scientists.

IV. Biology and Reproduction

A detailed study of these questions has been presented by Koford (1957). Yet, it is necessary to explain some objectives briefly and to add my own observations to elucidate the whole situation.

Apart from solitary animals two social groups of vicunas have to be distinguished, the family parties and the bachelor herds.

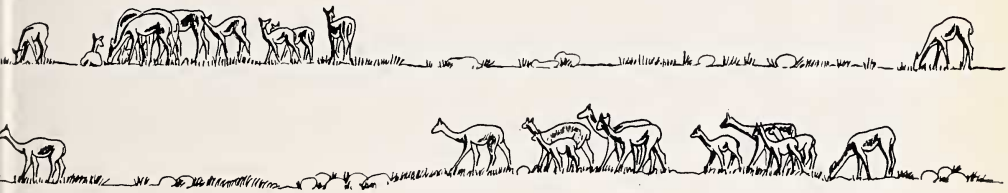

Fig. 9 (above). Vicunas family, the ♂ grazes apart from the ♀♀ and young. — *Fig. 10 (below).* Vicuna family on the move, lead by the ♂

Family parties (or bands) consist of several ♀♀ with young and are led by an adult ♂. They live in territories, the size of which depends on the availability of food and water. In the field, families are easily recognized due to lambs and their social organization. The male normally feeds alone, and stays 20 to 100 m away from the rest, which mostly form a close association (Fig. 9); when moving around, the ♂ leeds the band (Fig. 10). On the contrary, bachelor herds represent a leaderless aggregation (or concentration) of young or adult ♂ ♂ without any social order. They do not occupy territories but move around in so-called home ranges.

Adult ♀♀ give birth to a single lamb between February and March (Cabrera et al. 1960, Koford 1957). Koford found that about 17–18 % of the whole vicuna population are juveniles (less than one year old). According to my observations at Ulla-Ulla the percentage was even 19 % (in April and September). Koford reports a ratio of 100 ♀♀; 46 lambs for a good biotope at Hyalarco (Peru). At Ulla-Ulla, where the majority of the vicunas live on dry plains, with occasional access to the rivers, the ratio was 100 ♀♀ : 43 lambs. These are very good results if one takes the less favourable habitat into consideration. This was achieved through the presence of two game wardens who prevented poaching.

Fig. 11. Rounding up of vicunas at Cala-Cala, in the background stonewall of the enclosure (Photo by the South-American-Expedition Herre/Röhrs 1956)

The annual increase for Pampa de Galeras (Vicuna reserve in Peru) has been stated to be 26 % (Dourojeanni, 1968). This achievement is attributed to intensified protection and the favourable habitat. However, it must be considered that this data differs by 7—8 % from those of other wild populations and therefore it can be supposed that apart from juveniles, animals are included, which migrated into the reserve from adjacent areas due to relatively undisturbed living conditions (less persecution). How successfully small vicuna stocks can be increased under careful management is also demonstrated on the hacienda Cala-Cala (Peru). In 1919 20—30 vicunas were released in an area which was surrounded by stone walls (Fig. 11). Today about 600 individuals are said to live there (Grimwood 1969). In 1951 400 animals occurred (Koford 1957) and in 1957 500 (Herre 1963). Whether the maximum density has already been reached today, must be left to further investigations (see below).

V. Protection and Conservation

The opinion of many modern zoologists and conservationists tends more and more to the fact that nature conservation and species-conservation, can no longer only aim at protecting threatened animals and communities only in national parks and reserves (Herre 1963, 1969). These institutions are of course extremely important for guided research, education and tourism and often represent the only possibility to conserve large mammals, immense herds of game, predators or other biological and ecological particularities, but for comprehensive and broad nature conservation they are very often inadequate. Particularly in developing countries of Asia and South America, where successful parks hardly exist, we must realize that permanent conservation of wild animals is possible only, if a harmonious coexistence with the human population and their demands and the domestic stocks becomes established. It is impossible to expect from these people to set aside parts of their country for national parks, or to protect a wild animal because of its beauty, its rarety or due to its scientific value. Their traditional use of the environment for hundreds of years, their demand for meat and other animal products impede the understanding of the new situation which has created a menace for most wild animal populations due to modern weapons and human overpopulation. Therefore in developing countries long term conservation projects will only be successful, if priority is given to economic grounds, and by

demonstrating the benefit to the people which they can obtain if wild animals are subjected to a sound management. On account of its ability to utilize marginal areas which are unsuitable for agriculture and stock-breeding, the vicuna is well qualified for such projects and represents a natural resource for the underdeveloped areas of the Altiplano and the higher cordillera, which until now has been overexploited leading to near exhaustion.

Tourist attraction and utilization on the scale of wildlife management are the two great possibilities which large vicuna populations represent.

1. Tourism

The vicuna is one of the characteristic species of the highlands and because of its graceful shape and elegance one of the main attractions for the Bolivian and foreign tourist alike. To attract these people and to guide tourism, reserves should be established which then would produce additional income for the local inhabitants. By this the vicuna would soon become an economically important factor for the residents (Jungius 1970a) and due to the benefits which derive from its existence these people would change their attitude towards this animal and develop an interest in its protection.

At the moment there exists only one Vicuna Reserve. This is Pampa de Galeras in Peru (60000 ha, about 5000 vicunas). It was established in 1964 and since then the number of vicunas has increased. This can not only be attributed to the presence of game wardens who prevented poaching on a large scala and thus allowed more young to be raized (see above), but as well to the fact that vicunas migrated to this area, attracted by better living conditions. This phenomenon is very common and does not only appear here. First this was reported from African national parks (Stevenson-Hamilton 1957, Jungius 1971) where such events are well-known even in our day, for instance if we think of the increasing inflow of game, particularly elephants, into the Krüger National Park from the adjacent territories of Mosambique and Rhodesia (Pienaar pers. comm.), where they are subjected to intensive hunting.

The increase of the vicunas in Pampa Galeras is a great success for Peru and the reserve in particular. But it is still insufficient in regard to comprehensive vicuna conservation, because these stocks are by no means adequate to secure the vicuna's survival in the future. Therefore further reserves should be established, especially those for which preparatory work has already been undertaken, but the development of which ceased, due to lack of a financial support. In Peru: "Parque Nacional del Huascarán" (Dourojeanni 1968), and in Bolivia Ulla-Ulla (Jungius 1970).

2. Management of vicuna populations

For the successful management of the vicuna and for the creation of more reserves it is extremely necessary to start first with a comprehensive stock taking. Research on the entire situation of the vicuna should be undertaken and investigations should be made, where it would be wisest to apply the first means of conservation. Fundamental research on the basis of which better protection and management could have been achieved, were undertaken by Koford (1957). Because many questions could only be raised by him, many studies in the field of biology, ecology, population dynamics, and ethology need to be undertaken.

However, every biologist and nature conservator who plans to work in South American National Parks and Reserves must first realize, that it can not be the intention of prospective projects to transfer the resident campesinos and their alpacas from the area, because this is clearly politically impossible. Therefore all future

approaches must try to combine and balance these human elements with conservation attempts and aspire to establish a sound coexistence and co-operation. To make this true, numerous studies are necessary which have already been discussed in detail at another place (Jungius 1970, Herre/Jungius 1970), and therefore only a broad outline may be presented here.

a. Competition vicuna — domesticated animals, vicuna — other wildlife (besides other mammals, waterbirds, in particular the large flocks of Andean geese have to be considered).
b. What are the possibilities for a sound coexistence of all involved groups (vicunas, other wildlife, resident people, livestock).
c. How can vicuna populations be increased with a minimum of harmful effects to the animal breeders. Apart from means of game management and pasture management, possibilities should be evaluated to improve the quality of the alpaca stocks by modern breeding techniques, for instance the wool quality could be raised by selecting appropriate animals with the finest and softest fiber and of vicuna colour, which is already very expensive. By this a reduction of the alpaca numbers would be possible without financial loss and thus additional space would become available to wild animals.
d. Research on possibilities to subject large vicuna populations in the future to a controlled management, studies on game ranching, wool qualities, wool utilization (Inca management), cropping schemes etc.

Special attention must be paid to the question of the vicuna's "domestication", which has been raised repeatedly and for the success of which the hacienda Cala-Cala is always quoted, where 500—600 animals are reported to exist today (Grimwood 1969).

The breeder of these vicunas was Sr. Paredes who started with a founder population of about 20 animals in 1919. However, this population did not remain pure-blooded, because vicunas were crossbred with alpacas and lamas. If we examine this process under the aspects of modern genetics, the following results may derive from this:

1. The whole gene composition of a population is called the gene pool, from which every individual of the species gets a certain part, but it never possesses all genes (Wright 1945, Mayr 1963, Herre 1965). This entails that the individuals of a species differ phenotypically and genotypically from each other, however, without leaving the species type, only within which fertile reproduction is possible (Herre 1961, 1962, 1964, 1965). Moreover Mayr (1963) points out that in wild populations allelie genes are not principally responsible for the inheritance of corresponding characters (homozygosity), but that heterozygosity is the rule. Apart from this it must be mentioned that many hereditary factors do not become effective in large populations (recessive genes), but remain hidden as so-called kryptotypes (Osche 1965, Herre 1965). If we start breeding a small closed population isolated from the parental population, the following results may be obtained:
   a. Due to a low number of individuals the genetic diversity is drastically reduced (Mayr 1963).
   b. A large population starts from a small stock. In this process heterozygozity and the variability of characters increases, because most mutations are polygenic. According to the small founder population the possibilities for genetic recombinations increase as well, which can result in the creation of new characters.
   c. A similar appearance of gene recombination may be effected by changing the original or natural conditions of selection, due to which the genetic variation of the founder population is very often altered, new characteristics are established which shift or change the normal pattern of variation considerably, as is well demonstrated by the process of domestication (Herre/Röhrs 1971). Therefore

the new pattern of variation may be different from that of the parental population (genetic revolution, MAYR 1963).

If we apply this knowledge to the closed population of Cala-Cala, we can deduce that by breeding small groups of individuals continuously, the danger may occur that F-generations are produced, in which changes in the gene composition are possible due to a lack of natural selection or as a result of different selecting factors, by reason of which the "normal" appearance of the species is no longer maintained. Because only a small population of about 10 000 vicunas remains, such development must be observed anxiously and carefully. It can not be the aim of the vicuna's conservation to protect a certain type which appears to the conservationist as most "natural" or of outstanding "beauty", the view should be to protect a species as a whole within its natural bounds of variation.

2. PAREDES started very early to breed Paco-Vicunas (KOFORD 1957, HERRE 1963). These animals result from cross-breeding vicuna and alpaca (normally Suri race) and combine the high wool quality of the vicuna with the high wool-producting capacity of the alpaca. New investigations by HERRE (1952, 1953) and FALLET (1961) confirmed the statements of late, great mammalogists like HECK, KLATT, LÖNNBERG, TROUESSART, that the alpaca and the lama derive from the guanaco. Therefore crossing vicuna and alpaca implies interbreeding of two species, which can only be achieved by applying particular expedients, and result in frequent sterility of the hybrids.

These hybrids were not isolated from the other individuals, neither selected on fertility for further breeding attempts, but left uncontrolled running around with the vicunas. This may have had incalculable consequences for the genetic composition of the remaining vicunas, which can not be overlooked today. Slides from Cala-Cala, produced by the South American Expedition HERRE/RÖHRS 1957, show already many vicunas which deviate from the normal picture of the species considerably, and seem to represent either paco-vicunas, lama-vicunas, or bastards between vicuna and paco-vicunas or lama-vicunas.

From this we may conclude, that due to uncontrolled keeping conditions of vicunas, lamas, alpacas and hybrids an extensive crossbreeding and mixing of the population was possible, resulting in a hybrid population of 150—200 specimens today (GRIMWOOD 1969). This implies that only 400 to 450 vicunas are left at Cala-Cala. Whether the majority of these is still of pure blood or affected by interbreeding and gene revolution, which may have caused considerable deviations from the normal picture of the species, must be left to further investigations which are very much needed before this area is opened up and the animals allowed to move around unimpeded. For the same reasons the redistribution of these animals for purposes of restocking must also be avoided.

At the moment the future of Cala-Cala is very uncertain, because of the Peruvian Government's Agrarian Reform. But as the preservation of this institution is of great importance for the local campesinos, the Peruvian Government, and national and international scientists alike, I want to submit some recommendations for the further maintenance of this farm. On account of the biological conditions, the technical installations (buildings, enclosures, tools etc.) and the sociological situation (Reform Agraria) this area does not lend itself at the moment to establishing a national park, but there exist very favourable conditions to create here an agricultural experimental station. This would solve best the difficult social-political situation and moreover be to the greatest benefit to the residents, who are now about to take over the administration and responsibility of this extensive estate. The partition of Cala-Cala would be very unfavourable, because the huge vicuna concentration would be destroyed which is the only basis for a successful management on a large scale. Moreover it is first necessary to investigate to what extent the vicuna population has remained pure, to avoid threats

to the purity of other small populations on nearby farms (like Checayani), which could lead to the crash of several neighboring populations due to their low numbers and thus produce an immense economic and cultural loss.

If run by the government or by the local community of the campesinos, this experimental station could evaluate the practical experience from many decades and continue the work on a scientific basis. With the assistance of Peruvian teachers and international experts, young Peruvians could obtain an all-round education in the field of animal breeding, animal husbandry, domestication problems, game-ranching etc. (see below). To start this, the following activities are recommended:

1. To maintain pure-blood vicuna stocks outside the hacienda, efforts should be made to avoid catching vicunas on Cala-Cala for reintroduction purposes into other areas or for breeding in zoos.
2. It is indispensable to ascertain to what degree vicunas are mixed with alpacas and lamas.
3. Hybrids should be separated from vicunas and kept isolated.
4. To supply the vicunas with new blood, breeding with new individuals from outside (possibly Pampa Galeras) should start.
5. Guided cross-breeding of vicuna ♂♂ and alpaca ♀♀ should be started on the basis of modern genetic knowledge. Experiments on artificial insemination should be commenced. If this were successful any number of paco-vicunas could be produced quickly which could be used until the end of their lives (8—10 years).
6. Research on physiology, reproduction, competition, wool qualities and wool production (for instance how often the animals may be shorn) pasture management, parasites and their control, etc.
7. Apart from this there is the unique possibility to investigate to what extent vicunas may be subjected to economical game ranching (catching of vicunas for shearing, harvesting of surplus males) since the necessary facilities already exist.

3. Improvement of the alpaca-stocks as a means of vicuna-conservation

With regards to increased production of high yields of good quality wool, an improvement of the wool quality of alpacas should be attempted. Thus the needs of the industry for fine fibres could be satisfied and the stress would be taken from the vicuna. The South America Expedition Herre/Röhrs 1957 brought wool-samples from alpacas which are of similar quality and fineness to vicuna wool. Therefore it can be positively assumed that large stocks of alpacas with the finest fibres, of vicuna colour and vicuna quality could be bred by selection with modern genetic knowledge. As well as the higher wool-production, alpacas have the advantage that their wool is longer and is thus easier to use in spinning. That there must already be a considerable amount of alpaca wool on the market, may be elucidated by the following facts:

In 1965 for instance, Bolivia exported 5 t of vicuna wool. If one considers that one vicuna produces annually 120—180 grams of wool, one can deduce that this represents material from 27 000 — 40 000 animals. Until now vicunas can not be shorn in this quantities (see above) and therefore the animals had to be hunted and killed. If we assume that from 1950 to 1970 about 400 000 vicunas had been slaughtered (see above), this implies about 20 000 per year in the whole range (during the early fifties this figure was certainly exceeded, and in the late sixties the numbers did not come up to this estimate). As there are similar export data from other years, we may deduce with certainty that they are too high and beyond the productive capacity of the vicuna even under these conditions of overexploitation. Moreover it must be taken into consideration, that not all products from hunted

vicunas were exported, for a considerable amount remains always in the country (national industry, tourism, local consumption). Therefore this may support the estimation that about half or 1/3 of the exported vicuna wool was made up by alpaca products under the seal of "vicuna quality". A similar classification for high-grade quality could be given to alpaca wool which really could compare with that of the vicuna due to scientific breeding and careful selection. By this the requirements for high quality wool would be satisfied without subjecting the last vicunas to a dangerous and severe harvesting, which they cannot withstand at the present moment.

Summary

Because of overhunting nearly 400 000 vicunas have been eliminated during the last 20 years. There remained a world population of about 10 000 individuals, 1000 to 1500 of those are found in Bolivia. They survived in small populations or in scattered groups in the dryest areas of the Altiplano and in remote valleys of the Cordillera.

The vicuna represents a very important natural resource for the residents of the Andean Highlands, the development of which would be to their great benefit. A comprehensive protection of the vicuna can only be achieved on the basis of a close co-operation with the local people. By starting a far reaching public relations campaign and educational programme, one could raise their commercial and cultural interests in the protection of this species.

The vicuna uses the habitat very often more intensively then domestic animals, particularly due to the ability to graze on very poor and short vegetation it utilizes areas which are not suitable for livestock or agriculture. Moreover it represents one of the main attractions for tourism. To attract these people, reserves should be established which raise the income of local people and provide facilities for education and research.

The situation of Cala-Cala is discussed where a "semi-domesticated" herd of about 400 vicunas exists. Due to the start from a small founder population and extensive cross-breeding with alpacas and lamas it is very uncertain to what extent the vicunas remained pure. Therefore distribution of these animals to zoos and other areas must be avoided until intensive studies have been undertaken. At the moment it would be best to establish here an agricultural experimental station, where research on game ranching and other possibilities of the vicuna's commercialisation could be investigated.

Zusammenfassung

Durch unkontrollierte Bejagung wurden in den letzten 20 Jahren fast 400 000 Vicunas ausgerottet. Die heutige Gesamtpopulation umfaßt ca. 10 000 Tiere, von denen noch 1000 bis 1500 in Bolivien existieren. Sie leben in kleinen Populationen oder in verstreuten Gruppen in den trockensten Gebieten des Altiplano oder in abgelegenen Tälern der Kordillere.

Für die Bewohner des Andenhochlandes stellt das Vicuna eine sehr bedeutende natürliche Hilfsquelle dar, deren Erschließung ihnen großen wirtschaftlichen Nutzen bringen würde. Ein umfangreicher Vicunaschutz kann aber nur in enger Zusammenarbeit mit der einheimischen Bevölkerung erreicht werden. Durch ein weitreichendes Erziehungs- und Aufklärungsprogramm, könnte ihr wirtschaftliches und kulturelles Interesse am Schutz dieser Art geweckt werden.

Oftmals nutzt das Vicuna den Lebensraum intensiver als Haustiere, besonders durch seine Fähigkeit spärliche und kurze Vegetation zu beweiden, erschließt es Gebiete, die für Haustiere oder Landwirtschaft unzugänglich sind. Weiterhin stellt es eine Hauptattraktion für den Tourismus dar. Um diese Menschen anzuziehen, sollten Reservate eingerichtet werden, die zugleich das Einkommen der Einheimischen heben und Möglichkeiten für Erziehung und Forschung bieten würden.

Die Situation von Cala-Cala wird erörtert, wo eine „halbdomestizierte" Herde von fast 400 Vicunas lebt. Weil dieser Bestand seinen Ausgang von einer kleinen Gründerpopulation nahm, in die zum andern Alpakas und Lamas eingekreuzt wurden, ist es sehr ungewiß bis zu welchem Grade diese Vicunas reinblütig geblieben sind. Darum muß vermieden werden, diese Tiere in andere Gebiete zu überführen oder an Zoos zu verkaufen, bevor nicht eingehende Studien durchgeführt worden sind. Zur Zeit würde es am günstigsten sein, hier eine landwirtschaftliche Versuchsstation einzurichten, wo Fragen des "game-ranching" und andere Möglichkeiten der wirtschaftlichen Nutzung des Vicunas bearbeitet werden können.

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Author's address: Dr. Hartmut Jungius, World Wildlife Found, Ch - 1110 Morges